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GEODESY.—*Gravity work at the second meeting of the International Geodetic and Geophysical Union.*[1] EMMANUELE SOLER, Royal University of Padua. (Communicated by W. D. LAMBERT.)

The International Geodetic and Geophysical Union, which was formed after the war for the purpose of promoting and coördinating investigations in geodesy and geophysics, held its first meeting at Rome in May, 1922. At this meeting there was but little discussion of gravity work.

The writer presented a note: *The establishment of an international gravity net* (*Sullo stabilimente di una rete gravimetrica internazionale*) which was published in the *Bulletin Géodésique* (No. 2, April, 1923), issued by the Section of Geodesy of the Union, and was intrusted with the duty of drawing up an international report on determinations of gravity between 1912 and 1922 and also some account of those made in 1922–24. This report, which is now in press and which contains 600 determinations of gravity made in this period, and also an account of the work in 1922–24, were presented at the Madrid meeting.

The facts brought out by the report, both in regard to the variety of instruments and in regard to certain diversities in the methods of observation and calculation prevailing in the various countries, brought home to the Section of Geodesy of the Union the necessity of appointing an international Committee on Gravity[2] to consider the various questions raised in the report and to establish general rules for coördinating gravity work.

In the first place the Committee recognized the difficulty of pre-

[1] Translated from the *Memorie della Società Astronomica Italiana*, Vol. III, New Series, by W. D. LAMBERT, U. S. Coast and Geodetic Survey.

[2] The Committee was as follows: E. Soler, Chairman; other members, Bowie, Perrier, Neithammer, Lenox, Conyngham, Matsuyame; A. Vening Meinesz, Secretary

scribing a single type of instrument for determining gravity, since it would be only unwillingly that the various countries would give up the instruments made in their own machine shops, or devised by their own geodesists. Instead of this, the committee deemed it desirable to recommend uniform standards both for the work of observation itself, and more especially for computing the precision of the resulting determinations of gravity; these standards can be applied whatever may be the pendulum apparatus used and whatever the method by which time is determined, whether astronomically or by radiotelegraphy.

The rules for the conduct of observational work deal especially with the following matters: (1) the desirability of continual verification of the constancy of the pendulums, a matter which may be tested by returning them frequently to the national base station, or to some other connected with the latter by determinations of great accuracy; (2) the method of arranging the pendulum observations with reference to determinations of time, and the limits of admissible error, which will vary with the importance of the station considered.

In regard to the computation of the precision of the results, on the proposal of Meinesz and of Niethammer it was recommended that account be taken: (1) of accidental errors of the period of the pendulums, as deduced from the values of the period of oscillation observed at a single station; (2) of the errors in the period which are constant at a single station but which vary from one station to another according to the laws of accidental error; (3) of errors more or less systematic in nature. For each of the above classes the errors intended to be included were specified.

The committee laid down certain criteria to be applied in the rather troublesome computation of the so-called topographic correction,[3] to be applied to correct the observed period of oscillation, for the effect of matter lying above the geoid and extending to a distance of 40 km. at least from the station.

It was voted to proceed with the correction, and this with all attainable precision, of certain national base stations, particularly of those neighboring countries which are members of the Union, that is, at the present time: Madrid, Paris, DeBilt, Proviantgaarden (Copenhagen), Uccle, Cambridge, Basel and Padua; some of these stations are not included in the international gravity net adjusted by Borrass

[3] [This is the topographic correction (Geländereduktion) of Borrass's reports on gravity. It is applied because the topography above the geoid is conceived as condensed upon the latter to form a surface layer of density proportional to the elevation. It is not the correction for the topography in isostatic calculations.—*Translator.*]

in 1909. This connection when made and the adjustment of the resulting net will form a supplement to Borrass's work.

The Committee again expressed the opinion that theoretical gravity should be calculated by Helmert's formula of 1901.

In this way and by means of the standards referred to above, which are given in full in the minutes of the Committee soon to be published,[4] conclusions were reached on some of the most interesting problems encountered in measuring gravity.

With regard next to the much-debated question of isostasy it was deemed desirable to have the values of gravity corrected not only by the classic methods of reduction of Faye[5] and of Bouguer, but also by the isostatic method, according to the methods proposed by Hayford and Bowie. At the instance of the committee on gravity the Section of Geodesy voted that those countries which might not desire, or might be unable, to establish an office for computations of this sort might apply to the U. S. Coast and Geodetic Survey which, after suitable financial arrangements had been made, would perform the computations for the gravity determinations made by the countries in question.

This decision has the advantage of opening the way to a knowledge of the so-called depth of compensation in various parts of the world by means of uniform methods of calculation and therefore of increasing the value of the conclusions that may be derived from this knowledge.

To complete the chronicle of the discussions on gravity at Madrid let me mention two important communications.

The first one referred to certain fundamental changes which might be introduced into gravity apparatus. General Ferrié and Colonel Perrier presented some remarks regarding a method which is being tested at Paris by the Service Géographique de l'Armée. In this method gravity is determined by means of special light waves emitted during the fall of a body.

Bowie referred to an apparatus of Michelson's[6] still in the experi-

[4] A brief summary of the deliberations of the committee is published in the Bulletin Géodésique, No. 4, (1924).

[5] [Faye's reduction = free-air reduction. Mr. G. R. Putnam has applied the term *Faye reduction* to a method, also used by Faye, in which the Bouguer reduction is applied to the topography between the level of the station and the "general level of the surrounding country" and the free-air method to the vertical distance between the general level and sea level.—*Translator*.]

[6] Cf. W. Bowie, Isostatic Investigations and Data for Gravity Stations in the United States established since 1915. (U. S. Coast and Geodetic Survey, Special pub. No. 99, Washington, 1924).

mental stage at Washington, with which gravity is determined by measuring with the interferometer the flexure produced by a weight applied to a quartz fiber and suitably arranged on the fiber itself. The second interesting communication was made by Vening Meinesz and dealt with the determination of gravity at sea.

Meinesz, who had studied in Holland a way of eliminating the effect upon the oscillations of the pendulum of those small movements of the ground, which are quite noticeable in that region, by means of a method based on the simultaneous swinging of several pendulums, believed that the same method could be applied to eliminate the effect of the motion of a vessel situated at some little depth below the surface of the sea, and that therefore it could be used in a submarine submerged to a depth of about 10 meters below the surface.

He used for the purpose a Stückrath outfit of four pendulums in the Dutch submarine KII and during the voyage of this vessel from Holland to Java he made determinations at 26 stations, some in harbors and some in mid-ocean.

The results, which are published in a note, *Observations de pendule sur la mer*, Delft, 1923, and were presented at Madrid, although provisional are very important.[7] The Section of Geodesy therefore expressed the hope that all nations having navies might be willing to repeat these investigations.

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Thus has been summarized in outline the work pertaining to gravity that was accomplished at Madrid, work which, as is evident, fared far better than the work done at Rome during the first meeting. So without going into discussions of new forms of gravity apparatus which are not yet well known and which may perhaps displace the pendulum, it may be said that the decisions reached regarding the methods of observation and of computation are certainly such as to ensure greater homogeneity in gravity work and greater rigor, and thus to make the results lend themselves more readily to geophysical inferences.

At this point I should like to emphasize the subject of the connection

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[Professor Soler may perhaps have confused the brief reference to MICHELSON'S apparatus in Special Pub. No. 99 with an oral account of the apparatus devised by Dr. F. E. Wright of the Geophysical Laboratory of the Carnegie Institution of Washington. In Michelson's apparatus the deflections of a small cantilever beam of quartz are measured with an interferometer; in Wright's apparatus the distortion of a coil spring made of quartz and loaded with a weight is measured on a graduated circle.—*Translator.*]

[7] MEINESZ has informed me that he is making modifications in the instruments used in the first voyage.

of this work with geophysics. Without dwelling upon the ever-glorious traditions of geodesy, it is certain that in all countries there has been accumulated an enormous mass of geodetic data.

This does not represent, however, merely a necessity of the past. The lively and interesting discussions in the Section of Geodesy at Madrid regarding the choice of an international ellipsoid of reference prove that this is a question of present-day interest. And it is a question that involves not merely theoretical necessity but also practical convenience.

It is well known theoretically that, whatever ellipsoid may be chosen to represent the earth's surface, there are always deviations of the latter from the *geoid*. It remains for geodetic research to determine these deviations in the best way, to deduce from them the curvature of the geoid and to give some idea as to the possible effect of these deviations on the determination of gravity.

But the practical point of view is no less important, since by the choice of a convenient ellipsoid the connections between the triangulations of adjoining states are made more certain, the results of leveling are rendered more valuable, and the solution of the various problems of a practical nature more simple. This ellipsoid should fulfil the following conditions: (1) the local deflections should be reduced to small amounts; (2) it should have only small deviations from the geoid; (3) it should be possible to pass by small changes of the semiaxes from this ellipsoid to the several regional ellipsoids used in various countries for their triangulations. The subject of a suitable ellipsoid is therefore not exhausted by classical investigations and always leaves open the way to further studies, which likewise have a practical bearing.

The fact that in investigating this ellipsoid of reference the results of astronomic methods were combined with more modern results from measurements of gravity is one of the many strong claims to distinction of the illustrious Helmert, who in 1901 calculated an ellipsoid from determinations of gravity known up to that time. This same ellipsoid now serves and will continue to serve, as has previously been mentioned, for the calculation of the theoretical values of gravity.

Thus the geodesists are applying to their fundamental—and inexhaustible—problem methods ever more and more modern, and these methods depend on results, like those of gravity determinations, which, along with others depending on determinations of longitude differences, latitude variations, and so forth, make up an aggregate of work which the geodesists, in addition to that done for their own special purposes, are making available for geophysical research. It is certain that this

work will go on being continually increased, discussed and modernized; but is likewise certain that it cannot be of use in geophysical problems unless serious steps are taken to secure the needful coördination.

Permit me to say here that as regards this coördination little has been accomplished so far by the International Union. At Madrid, as I happen to know, there was a meeting between certain delegates of the Section of Geodesy and the Section of Oceanography; from this resulted the decision to establish institutions for the study of earth tides in connection with oceanic tides. Certainly this is an important decision and one which may lead to interesting results in which geodetic investigations (leveling, etc.) may be combined with geophysical ones. Another meeting was held of the delegates of the Section of Geodesy and the Section of Meteorology and of Seismology, but as far as I recall, without practical results. All this is not very much.

The variety of problems is well known for which geophysics needs geodetic connections and in some countries, such as the United States, through the work of the Coast and Geodetic Survey, these connections exist and geodetic investigation with its application to problems of a geophysical nature goes on increasing. It is enough to mention the masterly investigations of Hayford and Bowie on isostasy. It is therefore to be hoped that it may be possible to establish within the Union closer relations between the various sections.

But, particularly as regards our own country, it is well to repeat the wish so competently expressed by Senator Volterra in his Presidential address before the Academy of the Lincei at its meeting of June 1, 1924, to the effect that not only should the National Committees take steps to unify by appropriate means the investigations of the various branches of the Union, but that institutions should also be established among us of a practical and experimental character, institutions which might bring about the necessary progress and the coördination needed in the various problems which bind together geodesy and geophysics.

Royal University of Padua.

January, 1925.

CHEMISTRY.—*Chemistry as a branch of mathematics.*[1] LEASON H. ADAMS. Geophysical Laboratory.

In selecting a title for this address, I have chosen "Chemistry as a branch of mathematics" in order that the title itself might emphasize

[1] Address of retiring President of the Chemical Society of Washington, January 14, 1926.

one of the important aspects of chemistry. It is my purpose to discuss some of the points of contact between chemistry and mathematics and to direct attention to the necessity of making more use of mathematical methods in chemical investigation.

Let us begin with a brief review of the origin and early history of chemistry, in order that we may better observe the place which it occupies among the other sciences and the general trend of chemical thought.

Alchemy. Chemistry had its origin in the ancient art, alchemy, which was first developed by the Alexandrian Greeks early in the Christian era. According to an old legend it was founded by the Egyptian god Hermes. For this reason the early alchemists were said to practice the hermetic art, and when they filled vessels with various mixtures and closed them up they placed on them the seal of Hermes, from which arose the term "hermetically sealed." The first well-authenticated event in the history of alchemy was the decree issued by the Roman emperor Diocletian in 290 A.D. ordering the destruction of certain books which contained, among other things, various recipes for making alloys simulating gold and silver and used in the manufacture of cheap jewelry.

It seems that originally these processes, which were kept secret by the priests, deceived only the outsiders, but that eventually the adepts succeeded also in deceiving themselves into believing that they could turn base metals, such as lead, into gold. This hope and belief furnished the incentive for chemical investigation—of a certain kind—extending over many centuries, first by the Greeks and Egyptians and later by the Arab and Roman alchemists. The development of alchemy took place along the theoretical as well as the experimental side, and if their experiments were few and inconclusive, their theories were numerous and detailed, as found in the abundant literature of alchemy. Many of these theories were founded on the idea of a *prima materia*, a single primitive matter of which all substances were composed. Other theorists, however, were more liberal as to the number of fundamental elements. Thus many adhered to Aristotle's system whereby the fundamental elements were earth, air, fire and water, while in the works of Basil Valentine sulfur, mercury, and salt were assumed to be the constituents of all metals. Perhaps the most interesting explanation of the genesis of metals is found in the writings of Vincent of Beauvais who held that there are four spirits—mercury, sulfur, arsenic, and sal ammoniac—and six bodies—gold, silver, copper, tin, lead, and iron. The metals are formed as follows: "Pure

white mercury, fixed by virtue of white non-corrosive sulfur, engenders in mines a matter which fusion changes into silver, and united to pure clear red sulfur it forms gold while with various kinds of impure mercury and sulfur the other bodies were produced."

Such was alchemy. The properties of a number of substances were known in a general way, but in more than a thousand years the alchemists had made but little progress beyond the knowledge and beliefs of the early Greeks and Egyptians.

The beginnings of chemistry as a science. Alchemy came to an end, to be replaced by what we now call chemistry, at the time (from 1600 to 1700 A.D.) when the idea of the transmutation of the elements died out. Although little real progress was made and although the main activities were in the line of industrial chemistry rather than in fundamental research, yet there were a large number of cultured men willing and eager to extend their knowledge of the properties and composition of all substances. Their failure to do so—except in a very limited way—is not to be attributed to a lack of brain-power or to an unwillingness to spend much time and effort on the subject, but rather to an inability to proceed along the right course. It is remarkable that the science of geometry had been well developed before even the earliest beginnings of alchemy—so well developed that today we have in common use a textbook, Euclid's Geometry, which is nearly 2000 years old. The ancients were fully capable of proceeding along the lines of pure logic, but they had no facility for properly combining hypothesis and experiment. Real progress did not come until they could preserve the proper balance between theory and observation.

Modern chemistry began in the period from 1700 to 1800. Its origin is inseparably connected with the names: Dalton, Boyle, Lavoisier, Priestly, Scheel, Cavendish, Bertholet. One of the first evidences of the real beginning of chemistry was the development of symbols and formulae. The alchemists were accustomed to represent the known metals by certain astronomical signs, namely those for the sun and 7 planets. Thus ☉ ☽ ☿ ♂ ♃ ♁ ♄ ☿ stood for gold, silver, copper, iron, tin, antimony, lead and mercury respectively. Since this provided for only 8 elements, Bergman added certain arbitrary symbols to the list: ⏣ ⏢ ⍜ ⍁ ⍀ ⍥ ⏥ + ⊕ ○ ⏃ ▽ ⩛ which stood for zinc, manganese, cobalt, bismuth, nickel, arsenic, platinum, metal, acid, alkali, salt, phlogiston, water, and alcohol. Dalton used a new and more consistent set of characters; for example, ○ ◑ ● ✇ ⊕ ◍ ◍ ⊙ represented, in order, hydrogen, nitrogen, carbon, phosphorus, sulfur, potas-

sium, sodium and oxygen. Finally Berzelius replaced the geometric signs with the letters now used.

Mathematical notation. The use of characters to represent elements s the first indication of a mathematical trend in chemistry. For the essence of every branch of mathematics is a set of symbols which represent quantities, qualities, and operations. Thus, the symbol AB may represent the length of a line extending from a point A to a point B, or the direction of the line (say, northwest), or the result obtained by multiplying a number A by a number B. In mathematics a set of symbols enables us to write a kind of shorthand whereby a statement concerning the relation between a number of quantities and requiring many complete sentences can be condensed into a few strokes of the pen. For example, the following collection of symbols $(a + b)^2 = a^2 + 2ab + b^2$ is the equivalent of the statement that:

> When one number is added to another number and when the sum is multiplied by itself the number obtained by this operation is identical with that obtained by multiplying the first number by itself and then adding twice the product of the two numbers and adding also the product obtained by multiplying the second number by itself.

To take an extreme case, the expression $R^{\mu}_{\alpha\beta\gamma}$, well known in a certain branch of mathematics, stands for a set of expressions[2] which would require many hours to state completely in plain English. In a similar but less striking manner every chemical equation is a statement in mathematical language of a number of facts concerning certain elements and compounds, and the difficulty of writing or speaking about chemical subjects without having recourse to the conventional symbolism can well be imagined.

To return to the history of chemistry: having been started in the right direction by the great hypotheses of Dalton and of Avogadro, the science developed steadily and ever more rapidly. The century that has just passed has seen chemists increase in number from perhaps a few dozen to tens of thousands; it has seen a vast accumulation of information concerning the properties and composition and reactions of substances; it has seen chemistry transformed from a mere hobby to a great branch of science and an indispensable factor in the world's most important industries. During this period workers in the field of chemistry were so occupied with measurement, with analysis and with synthesis that theory lagged far behind experiment. A great mass of uncoördinated and apparently unrelated data accumulated

[2] This is the Riemann curvature tensor; used in the theory of relativity.

and by its very magnitude and unwieldly character forced the development of theories or laws to harmonize and simplify the known facts. Chemistry was thus driven slowly and inevitably into mathematical-physical channels.

Abstract reasoning. Let us now consider the two ways in which we may look at chemical problems. People may be divided rather sharply into two classes depending on their ability to view things in the abstract. One class has no difficulty in visualizing the meaning of symbols and in forming a mental picture from an equation. The other class finds it difficult or impossible to do this and prefers the written word or sentence rather than a symbol which stands for it. All equations are poison to these people. We have here a difference of temperament rather than training. Each class has its own mode of thinking and its own method of attacking problems. The one type is found more often among the physicists; the other among chemists. It seems that in schools and colleges too little allowance is made for this condition. The kind of mathematics customarily employed in physics presents very great difficulties to most students of chemistry. However, to teach "Functions of a Complex Variable" to an unwilling chemist is no more foolish than to eliminate mathematics entirely from his course of study. Actually the amount of pure mathematics required in most branches of chemistry is small. Elementary calculus is as far as most need go, but what is more important than any specific mathematical subject is to have a certain type of mental training, a mental training requisite for a proper understanding of the physical meaning of a formula. Most people realize that geometry is not taught to high school students because they are likely to have any practical use for the relation between the exterior angles of triangles, but rather because geometrical demonstrations teach them to think straight and to proceed in a logical manner whenever they attack any problem.

Mathematics is an abstract science while chemistry is essentially a concrete science, but progress in any branch of science will be most rapid when it makes full use of the tools which the mathematician has provided. This is more evident in physical chemistry than in organic chemistry or biochemistry, but because of the inherently greater difficulties these parts of chemistry have not developed so far. Already, however, the methods of physical chemistry are being made use of in nearly every branch of chemistry and, a start having been made, it is to be expected that much of the apparent aversion to mathematical methods will gradually disappear.

Let us now consider a few examples of the mathematical aspects of chemical investigation—first a brief description of the elementary mathematical devices which are of most general use, and second a mention of certain branches of chemistry which are most intelligible when allowed to speak in mathematical language.

The graphical representation of data. In nearly all kinds of investigation, it is necessary to measure something, and if one of the measured quantities depends solely on one other quantity it is common practice to plot a curve. "Order and regularity are more readily and clearly recognized when exhibited to the eye in a picture than when they are presented to the mind in any other manner." However, it is seldom that the full possibilities of graphical representation are realized. In many instances it is advantageous to plot one quantity against the logarithm of the other quantity. This can be done either by finding the logarithms and then plotting in the ordinary manner, or, more directly, by the use of special coördinate paper with a logarithmic scale. By this means, curves having a logarithmic or exponential shape[3] become straight lines, or nearly so, and a straight line, of course, is much easier to draw and is more useful for extrapolation. In other cases it is convenient to use a double logarithmic scale[4]—so-called log-log paper.

Still more important for the chemist is a peculiar scale in which the logarithm of one quantity is plotted against the reciprocal of the other. This is almost indispensable when dealing with vapor pressures or with equilibrium constants, and it is very surprising to observe the large number of those in chemical work who are not familiar with this procedure.

The deviation curve is a valuable aid in plotting certain kinds of data. It is difficult to plot data accurate to one part in one thousand on a sheet of reasonable size. But by plotting the differences between the observed points and some arbitrary line which approximately fits the data, it is possible to obtain a satisfactory representation on a small sheet of coördinate paper and to show irregularities which are invisible on the ordinary plot.

Selection of an equation. This brings us to one of our most common difficulties—the selection of an equation to represent a given set of data. To this goal there is no royal road. It requires the use of the

[3] That is, curves approximately represented by the equation $y = ab^x$, where x and y are the variables.

[4] This makes a straight line of the function $x^a = by^c$.

simple mathematical devices which have been provided for us, combined with as much common-sense and experience as we can bring to bear on the problem. In general, the best procedure is as follows: First, it is advantageous to familiarize oneself with the appearance of a number of the simpler types of curves. Several of these[5] may be plotted on a convenient scale and kept for reference. Then, having plotted the data in question, we compare with the reference curves the shape of the curve so obtained, and if one is found which resembles the experimental curve we use this as a clue in replotting the data so that nearly a straight line is obtained. If satisfactory, we then use the graph to determine all but one of the constants of the equation and calculate the remaining constant from the equation and the data.

A more elegant method for determining the constant of the chosen equation is to use the method of least squares. This is a good plan—for those who can do it. Nearly as good results are obtained by averaging the points in groups so as to obtain as many "average points" as there are constants in the equation and then solving directly for the constant.

As a last resort, when all other methods fail, the data may be fitted to a power series

$$y = A + Bx + Cx^2 + Dx^3 + \ldots\ldots$$

using enough terms to make the curve fit the data to a sufficient approximation. This is the most common method and the least satisfactory.

What has been said so far refers to the case of two variables only. With three variables (for example, P, V, and T) graphical representation requires the construction of a solid model, or the drawing of contours on a plane, while with four variables the case is hopeless unless one is clever enough to draw a projection of a four-dimensional surface on a three-dimensional solid.

The Phase Rule, and chemical thermodynamics. A great deal of the mathematical part of chemistry has centered around the Phase Rule. It was in 1875 that J. Willard Gibbs clearly defined component and phase and brought forth his famous generalization which stated that the number of phases in equilibrium could never exceed the number of components by more than two (thus, with a mixture of common salt no more than four phases can exist together), and that the system

[5] For example a simple parabola, $y = a + bx^2$, an hyperbola, $y = \frac{a}{x} + b$, a cubic, $y = a + bx^3$, the exponential relations (footnotes 3 and 4), or the equation $\log y = \frac{a}{x} + b$.

gained an additional degree of variability, or degree of freedom, for each phase short of this number. It is safe to say that without the aid given by this rule a satisfactory investigation of the chemistry of solutions and complex mixtures would have been quite impossible. After being discovered by Gibbs the Phase Rule was unnoticed for many years, but was finally rediscovered and put to good use. We might wonder why this important Law should remain dormant for so long. The answer is found in the way in which it was first announced. On page 96 of "Equilibrium of heterogeneous substances"[6] we may read as follows:

"If a homogeneous body has n independently variable components, the phase of the body is evidently capable of $n + 1$ independent variations. A system of r coexistent phases, each of which has the same n independently variable components is capable of $n + 2 - r$ variations of phase. For the temperature, the pressure, and the potentials for the actual components have the same values in the different phases, and the variations of these quantities are . . . subject to as many conditions as there are different phases. Therefore, the number of independent variations of the values of these quantities, i.e., the number of independent variations of phase of the system, will be $n + 2 - r$."

This is the Phase Rule. When we note that this paragraph occurs in the middle of a paper containing 300 pages of rather forbidding mathematics we should not be surprised that it escaped attention for so many years.

The Phase Rule was derived from the principles of thermodynamics and is only a part of a great system of chemical thermodynamics developed by Gibbs and published in a paper which is probably the most important paper in all physical chemistry.

Thermodynamics attempts to reduce to their simplest form all laws relating to chemical systems. It states that in a homogeneous mixture, i.e., a phase, the properties of the system are completely determined if we know four quantities, which are designated by the letters P, T, V, and S. Of these, the first three are readily understood to mean the pressure, temperature, and volume, respectively, of the given phase. The fourth stands for a quantity called entropy; and why, we may well ask, do we introduce this strange interloper among the other sane and respectable characters? The answer is that in no other way has it been found possible to deal with the laws of solutions in a direct, logical way and to take advantage of simple mathematical formulation.

The four quantities mentioned above are sufficient when we deal with

[6] J. Willard Gibbs, Scientific Papers. Vol. 1: p. 96.

a system in which material is neither added nor taken away. To allow for variation in amount of each component we must add another quantity, μ, one for each component. There is a simple fundamental equation connecting the quantities P, T, V, S. and the μ's, from which we can proceed, by what is really simple calculation, to the formulation of the freezing-point Law for solutions, or the laws relating to vapor pressure or osmotic pressure, or, indeed, any of the solution laws. The desired relations can be derived separately from the same starting point, or they can be combined in a single equation:[7]

$$(S'' - S')\,dT - (V'' - V')\,dP = m'_1 \frac{\partial \mu''_1}{\partial x''_1}\,dx''_1 - m'_2 \frac{\partial \mu''_2}{\partial x''_1}\,dx''_1$$

By a few strokes of the pen any of the solution laws can be written down at once, if this equation is before us. This applies to the ordinary case of two phases and two components. For more complicated cases a similar equation can be written.

This same system of physical chemistry can easily be made to take account of the additional factors, surface tension and the action of gravity. In the latter case we are enabled to write, without long calculation, an equation giving the difference in composition of a solution at the top and at the bottom of the vessel containing the solution. Furthermore, we may take account of another variable and deal with electrolytic cells, the E.M.F. of which can be connected with the properties of the substances which take part in the chemical reactions within the cell. It is for this reason that E.M.F. measurements have contributed so much in extending our knowledge of physical-chemical systems.

The thermodynamical treatment of chemistry is indispensable in a certain very interesting field of work, the study of the properties and reactions of systems under high pressure. If more time were at my disposal I should like to point out the ways in which certain simple mathematical methods are of service in such investigations. Suffice it to say that by taking advantage of the relations existing between apparently unrelated quantities it is possible to arrive at satisfactory results by indirect methods where it would be impossible to measure the desired effect directly.

Chemical affinity. At this point I wish to mention one of the con-

[7] In this equation the superscripts refer to the phases and the subscripts to the components. The total amount of one component in the given phase is m_1, and its weight percentage is x_1.

cepts of chemistry which has always proved of great interest. I refer to chemical affinity. This term has long been used in a vague way to indicate the force which causes atoms to combine and which determines whether or not a chemical reaction will proceed in a given direction. Thermodynamics has supplied the means of giving this qualitative term a quantitative significance. Instead of dealing directly with forces, we take advantage of the fact that a force may be measured by the work which it does, so that affinity is defined in terms of work or energy units. Thus the affinity of hydrogen for oxygen is measured by the work which may be obtained from the reaction in which they combine, and the affinity of hydrogen for chlorine may be defined in like manner. A quantitative comparison of the relative affinity of hydrogen for oxygen and for chlorine may then be made. It turns out that chemical affinity defined in the proper way is closely related to the quantity μ which occurs so prominently in all chemical thermodynamics; in fact, the two are nearly identical.

The mechanics of the atom. The last subject which I wish to touch upon is sub-atomic chemistry, that is, the nature of the interior of the atom. This most vital and fundamental part of chemistry has made great advances in the last two decades, having received its impetus hrough the discovery of X-rays and of radioactive substances. The internal structure of the atom is no longer a complete mystery. The physicists have apparently claimed this territory for their own, and it must be admitted that the great fundamental discoveries in this field have been made by physicists. Their remarkable progress has been largely due to the fact that they did not fail to use all possible mathematical tools including the most profound analytical methods.

The atom is now seen as a minute core or nucleus surrounded by a swarm of electrons, from 1 to 92 in number, at relatively great distances from the nucleus. The weight of the atom is determined mainly by the nucleus; practically all other properties are fixed by the number, position, or motion of the electrons. In particular, chemical valence depends mainly on the exterior electrons, and thus the idea of valence has come to have a fuller and more definite significance.

A number of new theoretical developments have led to great advances in our knowledge of the structure of the atom. In certain atoms the physics of their interior is so well known that the wavelength of light emitted by it is known not merely to within one per cent or to within one-tenth per cent, but to seven significant figures.

The study of the atom has been resolved into a question of mechanics, mechanics of a very queer kind involving the quantum

hypothesis, the theory of relativity, and other ultra-modern notions. There is evidence that in certain instances the electrons are revolving around the nucleus, and that in other cases they occupy relatively stationary positions. The final solution of these problems is not yet in sight. But it is not too much to expect that the interior of the atom, viewed as a problem in geometry and mechanics, will ultimately be completely solved and that we shall then be able to predict the properties of atoms and compounds, the reactions between them, and the possibility of the existence of unknown compounds. Chemistry will then have still more of a mathematical complexion.

In conclusion, I wish to quote some remarks by a distinguished chemist, Professor A. Crum Brown of the University of Edinburgh. More than thirty years ago he said:[*]

"Another frontier of chemistry is that which looks towards those regions of physics which have come more or less completely under the control of the great empire of mathematics. And here both the work done from our side and that done from the mathematico-physical side has special interest for us. For we may expect chemistry to undergo a very great and revolutionary change when the frontier comes to be explored and cultivated. We shall then be separated by an imaginary line from the mathematical sciences, and mathematical methods will rapidly be applied to chemical questions. Chemical methods will still be used. The most perfect dynamical explanation of chemical constitution and chemical change will not enable us to dispense with the old processes of analysis and preparation. The chemist will still be the man trained in the chemical laboratory, and all the mechanical parts of the work will still be done by him. But, unless he learns the language of the empire, he will become a provincial, and the higher branches of chemical work, those which require reason as well as skill, will gradually pass out of his hands. This must not be, and the younger chemists can prevent it. Let them while there is time learn the language of the empire. Let them become fluent and ready in its use; let them read with care the work that is being done on the border between chemistry and mathematical physics, and, as they find opportunity, do such work themselves, and so be ready to take their part in the union which will certainly come."

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

186TH MEETING

The 186th meeting was held in the assembly hall of the Cosmos Club on the evening of Thursday, March 20, 1924.

Dr. R. M. YERKES, of the National Research Council: *Psychology as Social Biology.*

[*] Trans. Chem. Soc. (London) 61: 478. 1892.

Psychology is now using the methods of the physical and biological sciences. At the same time it has important social objectives. On these grounds it may be considered a department of social biology. Recently differentiated from philosophy, psychology is actively engaged in trying to find itself and in delimiting its scope.

Confusion in the lay mind as to what psychology really is and may legitimately undertake to achieve is due largely to duality of interest and method within the science. On the one hand there is the subjective interest which promotes psychology as the study of the self (introspective psychology); on the other hand there is the objective interest and bias which limits attention to the study of behavior, one particular brand of which has come to be known as "behaviorism."

To the speaker both of these types of psychological interest appear legitimate and worthy of cultivation. The introspectionist and the objectivist alike have their opportunities to contribute to our knowledge of mental constitution. Their activities should be supplemental, and there is no apparent reason for fretting about their relative importance.

Since "human nature" is complex and highly variable, analysis is requisite to the successful measurement of traits. Most so-called "mental tests" measure we know not what! They undoubtedly are useful in the present desperately crude state of popular knowledge, but they are remote from the scientific ideal of method. The psychologist as investigator undertakes to measure specific and definite functions or "unit characters" of behavior. The majority of "testers" deal with human nature in large lumps and without much concern about their composition or the variability of their constituent parts.

Not a few laymen seem to believe that "test score," "mental age," and "intelligence quotient" are comprehensive, if not complete, descriptions of mental constitution. Instead, they are merely fragments of an ideally complete description, for experience and behavior are almost discouragingly many-sided. Even "intelligence" (defined as individually adaptive behavior) is complex, and its reasonably complete description would entail the measurement of scores if not hundreds of specific traits or functions. As in the case of physique, so in human behavior, many dimensions must be taken before we can safely compare individual with individual or group with group.

In a recent book by Dr. Rudolf Lämmel, *Intelligenzprüfung und psychologische Berufsberatung* (Oldenbourg, Berlin, 1923), the point here made is effectively visualized. By a system of polar coördinates the author simply presents the results of a reasonably comprehensive series of measurements of reactive capacity.

In Dr. Lämmel's figures, designated as "ingenogramms," the traits measured fall into eight principal categories, roughly translated as observational ability, memory, technical aptitude, attention and concentration, imagination, artistic ability, judgment or critical ability, and maturity. Within each category several traits or functions are measured. For instance, one ingenogramm represents the results obtained with a class of forty-four boys. A perfect circle represents the average for the group, since the average for each trait measured is arbitrarily located at a certain fixed distance from the center of the ingenogramm. The variability (plus and minus) of the average or mean is represented by polygons without and within the perfect circle. The innermost polygon of the ingenogramm represents minimal measurements for the group of individuals observed. The outermost polygon similarly represents maximal measurements.

By comparison with the ideal individual of the group, as represented by the perfect circle, there appear in this ingenogramm the figures which indicate the measurements obtained from the poorest pupil in the class and for the best pupil. Thus the ingenogramm makes possible ready comparison of the reactive traits or capacities of an individual with the average or ideal for his age, sex, race, etc., or with any other individual.

The value of the ingenogramm of course depends upon the nature and value of the traits which are chosen for measurement and the accuracy of the observations. Granted reasonable wisdom in choice and accuracy of measurement, it would appear highly desirable that each of us, for educational, vocational, and varied other purposes, be provided with his ingenogramm! (*Author's abstract.*)

Dr. L. L. THURSTONE of the Carnegie Institute of Technology, Pittsburgh: *Psychology in employment.*

187TH MEETING

The 187th meeting was a joint meeting with the Botanical Society and was held at the Administration Building of the Carnegie Institution of Washington on the evening of Monday, March 24, 1924.

Prof. JEAN MASSART, of the University of Louvain: *The internal sensations of Araucaria excelsa.*

There are six kinds of buds on Araucaria: (1) A terminal bud, (2) the dormant buds of the main stem. These can develop into nothing but main stems, no matter how they are treated or where they are placed. (3) The active buds at the tips of the primary branches, (4) the dormant buds on primary branches. These can develop into primary branches. (5) Active buds at the tips of subordinate branches, and (6) dormant buds on subordinate branches. These can be made to develop only subordinate branches.

A number of experiments were set forth, showing in most striking fashion that each of these classes of buds was able to develop only in its own fixed way. Some of the experiments shown had continued for more than twenty years.

Experiments were also shown to demonstrate the exchange of stimuli from one part of the plant to another. A plant, for example, was grown with one half in bright sunlight and the other half moderately shaded. The shaded half soon became unhealthy and died, though another plant, the whole of which was shaded, was not injured by the same degree of shading as was fatal to the part of the plant which remained partly in the sunlight.

When the plant is turned into a horizontal position the primary branches, which originally came out at equal angles around the stem, are raised or depressed, as the case may be, to bring them closer to the horizontal position they normally occupy.

When a plant was turned up-side-down and its axis prevented from bending upward by a weight, the older lateral branches gradually twist to bring their leaves into the original dorsi-ventral position. Twisting begins at the tip of the branches and gradually proceeds toward the base. In young branches where dorsi-ventrality had not yet been established the face now upward became dorsal and that downward became ventral without any twisting or turning. A plant that had been left in the reverse position for several months was again turned to a normal position. The old branches twisted again into either the same or the reverse direction to assume their proper dorsi-ventral attitude in the new position, but the young branches, which had assumed the reverse position without twisting bend up and over the top of the plant, assumed their proper dorsi-ventral attitude on the opposite side of the stem, forming by their bending a curious twist at their bases. (*Abstract by* R. F. GRIGGS, *Secretary of Botanical Society*)

188TH MEETING

The 188th meeting was a joint meeting with the Chemical Society and was held in the assembly hall of the Cosmos Club on the evening of Thursday, May 15, 1924.

Prof. LEANOR MICHAELIS, of Berlin: *The theory of acid-base equilibria and its application to biochemistry.*

189TH MEETING

The 189th meeting was a joint meeting with the Chemical Society and was held in the Auditorium of the Interior Department on Tuesday on the evening of October 7, 1924.

Prof. S. B. L. SORENSSON of Copenhagen: *Osmotic pressure of protein solutions.*

190TH MEETING

The 190th meeting was a joint meeting with the Philosophical Society and was held in the assembly hall of the Cosmos Club on the evening of Saturday November 1, 1924.

Prof. HENRY NORRIS RUSSELL of Princeton: *Recent advances in our knowledge of the stars.* Author's abstract appeared in THIS JOURNAL: **15**, 17, 1925.

191ST MEETING

The 191st meeting was a joint meeting with the Philosophical Society and was held in the assembly hall of the Cosmos Club on the evening of Saturday, November 15, 1924.

Professor CHARLES FABRY of Paris: *Thirty years in spectroscopy with the interferometer.*

The speaker gave many personal reminiscences and told of the difficulties encountered with primitive, home-made apparatus, very different from the finely finished instruments now in use.

192D MEETING

The 192d meeting was a joint meeting with the Chemical Society of Washington, the Baltimore Section of the American Chemical Society, and the Medical Society of the District of Columbia, and was held in the assembly hall of the Cosmos Club on the evening of Thursday, December 11, 1924.

Lieutenant Colonel E. B. VEDDER of Edgewood Arsenal: *The toxicity of lead tetraethyl and other substances.*

A number of men handling lead tetraethyl recently in two large factories became ill and some died, and there has been much newspaper talk about "insanity" or "loony" gas, names given to the ethylated gasoline, and its distribution has been prohibited in New York City. Literature was cited showing that while the ordinary symptoms of lead poisoning are of a chronic nature, lead encephalopathy, the symptoms of which do not differ markedly from those of lead tetraethyl poisoning, is of frequent occurrence. As reported by physicians, the symptoms of poisoning by lead tetraethyl are as follows: The blood pressure and body temperature fall, and the heart action becomes low; there are digestive disturbances, such as loss of appetite, vomiting and diarrhea; vertigo may be present; the red blood corpuscles show marked changes, and the blood becomes noncoagulable; there is no cyanosis, shortness of breath nor headache, but following these symptoms there are in severe cases other phenomena indicative of profound cerebral disturbances. There are persistent insomnia, delusion, extraordinary restlessness and talkativeness; the gait becomes staggering like that of a drunken man but there is no

paralysis nor convulsions; there is exaggerated movement of the muscles and the patient becomes violently maniacal, a condition that is not remedied by morphine. The lethal dose by skin application is 0.6 cc. and 0.3 cc. per kilogram respectively for guinea pigs and dogs, but an animal can be easily saved if washed within a half hour after exposure with kerosene followed by tincture of green soap. The toxicity of phosgene by inhalation is about ten times that of lead tetraethyl and mustard gas is about twenty times as toxic, yet these are manufactured by the ton with safety. In the manufacture of this substance workmen should be protected against its vapors and the possibility of getting the compound on their skin. Gas masks and gasoline should always be at hand in case of accident. There is some public hazard as the result of the general use of ethyl gas, both through skin application and by inhalation, but the author assumes that this may be reduced to very small proportions by issuing proper warnings and by education. No cases of poisoning following the distribution of ethyl gas have been reported, nor have animals subjected to the exhaust gases from ethylated gasoline suffered any noticeable ill effects that could be attributed to lead poisoning. Carbon monoxide is infinitely more dangerous in a closed garage.

Lead tetraethyl is such a valuable commercial asset that it cannot be permitted to be dropped. Before it can be permitted to come into general use adequate provisions must be made for its safe manufacture, and quite extensive studies should be made as to the possible poisonous accumulative action when it is used over long periods of time. (*Abstract from author's paper by* V. K. CHESTNUT, *Secretary pro tem of Chemical Society.*)

Col. VEDDER also made a brief statement regarding the use of chlorine in the cure of colds. Lack of success by others has been found to be due to the fact that the optimal concentration was not employed.

193D MEETING

The 193d meeting was a joint meeting with the Archeological Society and the Anthropological Society, and was held in the auditorium of the New National Museum on Tuesday, December 16, 1924.

Count BYRON KHUN DE PROROK: *The Carthage excavations of 1924 and the dead cities of the Sahara.* The site of ancient Carthage is one of the most beautiful in the world. The ruins of the city stand on a peninsula sixteen miles north of Tunis. Excavations there have been made spasmodically for forty years, but barring the Punic Tombs discovered by Father Delattre, only a single solitary Punic ruin has been found. This is being excavated at the present moment and is revealing each day new light on the art and religion of a lost empire.

The ruins of the first Carthage are still beneath the surface of the other layers of different civilizations. In one portion of the excavations seven strata of different periods of man have been uncovered—seven cities one above the other!

Ancient Arab Carthage has produced some beautiful examples of glazed pottery. The crusade of St. Louis of France in 1370 left some interesting coins. The Byzantines, who ruled there for over a hundred years, have also left traces of their dominion—a church, several houses, fortifications, and debris of all sorts. The Vandals destroyed more than they left, and though coins and armor and tombs of the Vandal period exist, yet it is mostly of their predecessors, the Romans and the early Christians, that we find the greatest number of ruins and remains. The aqueduct, the theater, the odeon and vast cisterns have been partly uncovered, but the wonders of Carthage to be

visible today are the early Christian basilicas that have been found by Father Delattre, the great French scientist and dean of the North African explorers. It is due to him also that at Carthage there is one of the finest though least known museums in the world filled with treasures of many empires.

Carthage was the first city to use paving stones, and the historians speak of its houses as being seven stories high. Such edifices must have left foundations and it is our hope to find traces of the roads and forum of Punic Carthage this winter. Another site that is still a great mystery is that of the ancient ports. For several hundred years the vast fleets and armies engaged in the Punic wars sailed from the ports of Carthage. That is why we are starting extensive excavations to locate the harbors from which so much history sailed. From the ancient historians, Appian, Polybius and Pliny, we know that these ports were one of the wonders of the ancient world. They were two in number, the military port and the commercial port. A splendid circular colony made of giant columns surrounded the military port, in between which were hauled up the galleys. From the admiral's palace all the operations of the two great ports could be seen, and the fleets could be manœuvred and directed from one point. A channel to the sea was guarded at night with a mighty chain. Our efforts this winter will be centered on locating the quays and in digging shafts into the ground in search of the forum or agora that we know from the historians was adjacent to the ports. It is in this quarter that we are excavating the Temple of Tanit recently discovered. This is the first clue to Punic Carthage and it is producing great results.

In the work of this important clue to a lost civilization many scientists and students come from different institutions. The Abbé Chabot of the French Institute took charge of the deciphering of the Punic inscriptions. Messrs. Icard and Groseille of Tunis made the plans and drawings. Mr. Harden of the University of Cambridge was cataloguer and Mr. Bariere of the New York Times was photographer. The excavations were supervised by the director of the government services, by Mr. Duff of Oxford University and by myself. This is to give an idea of what a large staff is needed, in a single excavation. All the earth removed has to be sifted, often by hand sieves. Coins, jewels, cameos, amulets, beads, etc., etc., have been recovered this way in quantities. Five thousand coins have been dug up in six weeks.

The great depth of the excavation is also one of the great problems, and sometimes tons of earth have to be carried to the sea. The earth deposited on Carthage in the hollows between the hills, has been calculated to be as much as one yard a century! This means digging down twenty yards to get to the city that Scipio destroyed in 146 B.C.

The great romance of excavation is not only the objects and monuments of lost civilization that we may find, but also the revealing of new historic dates and the links between different races. For instance, near the rock bottom of the temple of Tanit, which means the oldest period, we have found traces of a great Egyptian influence, and the problem now presents itself: Were the people of the Pharaohs here before Dido and her Phoenicians?

We are also excavating an early Christian chapel filled with early Christian sculptures, inscriptions and statuettes. These statuettes are of great importance to the history of the early Catholic Church. (*Author's abstract.*)

The address was illustrated by moving pictures. Afterwards an opportunity was given to examine some of the objects described in the address.

WALTER D. LAMBERT, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY

932D MEETING

The 932d meeting was held at the Cosmos Club on Saturday evening, February 20, 1926. The meeting was called to order by President BOWIE at 8:18 with 58 persons in attendance.

LOUIS A. BAUER: *Are sun spots the direct cause of the earth's magnetic storms?* (Illustrated by lantern slides.) The remarkable and rapid increase in the number and size of sunspots during recent months and the severe magnetic storm of January 26th, which was accompanied by brilliant displays of polar lights and notable interruptions in telegraphic transmission, has called renewed attention to the precise relationship between eruptive solar phenomena and disturbances in the earth's magnetic condition.

In August, 1923, occurred the minimum average frequency of sunspots expressed by the relative number 0.5; sunspots of small area occurred chiefly on two days (20th and 21st) of that month. The average relative frequency of sunspots in December, 1923, was 2.8, in December, 1924, 16.5, but in December, 1925, it had risen to 100. It would not be surprising if the maximum relative frequency of sunspots occurred during this year (1926)—only 3 years after the year of minimum frequency. In general, the interval between the years of minimum and maximum sunspot frequency is about 5 years, and the interval, termed the solar cycle, between successive years of minimum, or of maximum, sunspot activity, is about 11½ years. It has occurred before that the interval between minimum and maximum sunspottedness was as short as 3 years; for example, 1766–1769, 1775–1778, 1784–1787 and 1867–1870.

The chief conclusions resulting from the investigations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington are as follows:

a. An exhaustive examination shows that none of the present measures of the sun's activity are adequate to explain the occurrence and magnitude of disturbances in the earth's magnetism. The energy required to produce a sunspot appears to be of a different character and magnitude from that required to derange the earth's magnetism, to cause polarlight displays and to interrupt telegraphic transmission on overhead and underground lines.

b. Neither the number, area, nor position of spots on the sun's visible disk may be taken at present as a safe index for the prediction of the occurrence of magnetic storms, or of the production of the electric currents in the earth's crust which are responsible for interruptions in telegraphy. There are at times notable magnetic storms on the earth when there is no visible disturbance on the disk of the sun presented to the earth.

c. While, on the average, there is a very high correlation between solar activity and the earth's magnetic activity, from year to year during a solar cycle, the correlation does not seem to be one of cause and corresponding effect, but rather one indicative of the fact that solar disturbances, and magnetic disturbances are effects of one, as yet undiscovered cause, which may simultaneously affect the condition of the entire sun. (*Author's abstract.*)

C. W. KANOLT: *The work of the Cryogenic Laboratory of the Bureau of Mines.* The Cryogenic Laboratory of the Bureau of Mines was established in 1921 for the purpose of supplying scientific data required for the designing and the efficient operation of plants for the production of helium from natural gas and plants for the repurification of helium after it had become contami-

nated with air during its use in airships. The work of the laboratory consists largely of determination of the properties at low temperatures of the constituents of the natural gas from which helium is separated by low-temperature fractionation. The properties investigated include vapor pressures, gas solubilities, specific and latent heats, and the liquid-vapor composition relations of mixtures. Also, special physical apparatus for use in helium plants has been developed. The research methods employed in the laboratory were described, without the presentation of numerical results. (*Author's abstract.*)

933D MEETING

The 933d meeting was held at the Cosmos Club on Saturday evening, March 6, 1926. The meeting was called to order by President BOWIE at 8:16, with 70 persons in attendance.

The program for the evening consisted of four papers constituting *A Symposium on Earthquakes*. The first paper was by F. A. TONDORF on *Earthquake study in the past—a retrospect*, and was illustrated with lantern slides. The second paper was by N. H. HECK on *Some important problems in seismology*, and likewise was illustrated with lantern slides. The third paper by WILLIAM BOWIE dealt with *Earthquakes from the isostatic view point*. The last paper was by A. L. DAY on *Local earthquakes*, and was illustrated with lantern slides. These papers appeared in full in the issue of the Journal of the Washington Academy of Sciences for May 4, 1926.

The papers were discussed by Messrs. HUMPHREYS, L. H. ADAMS, STOKELY, and HAWKESWORTH.

934TH MEETING

The 934th meeting was a special meeting held jointly with the Washington Academy of Sciences and the Chemical Society on Thursday, March 18, 1926, at the Cosmos Club. The meeting was called to order by President SMITHERS of the Chemical Society at 8:15 P. M., with about 200 persons in attendance.

The program for the evening consisted of a paper by Dr. EDWIN E. SLOSSON on *The chemical interpretation of history*.

H. A. MARMER, *Recording Secretary*.

SCIENTIFIC NOTES AND NEWS

The annual excursion of the Petrologists' Club took place on May 7 and 8, with sixteen in attendance. The territory covered was principally in the South Mountain region of Pennsylvania near the Maryland line and about ten miles west of Gettysburg. The party proceeded from Washington by automobiles and spent the night of the 7th at Gettysburg. Among the features of special interest were: the "Devil's Racecourse," a boulder flow in the Cambrian quartzite region; outcrops of the pre-Cambrian basalts and rhyolites; sericite schists resulting probably from tuffs; unusual crystals of piedmontite, a manganese epidote; piedmontite schists and greenstone schists, quarried for use in making colored roofing materials; and copper ores, including native copper, occurring in associations similar to those of the Lake Superior copper district. G. W. STOSE and E. T. WHERRY acted as guides for the party.

The Pick and Hammer Club met at the Geological Survey on April 24. F. E. MATTHES spoke on *Glaciation of San Sacinto Park in southern California*, and C. K. WENTWORTH demonstrated his device for projecting topographic maps into block diagrams.

The annual meeting of the District of Columbia Chapter, Society of the Sigma Xi, was held at the Bureau of Standards on May 3. R. H. SARGENT of the U. S. Geological Survey gave an illustrated lecture on *Discovery of volcanic craters of unusual nature on the Alaskan Peninsula.* The lecture was preceded by five-minute contributions to knowledge by E. E. SLOSSON on *Soya bean oil products and synthetic rubber;* W. T. LEE on *The Carlsbad caverns;* R. B. SOSMAN on *A newly-discovered discontinuity just beneath the grantic shell of the earth;* R. F. GRIGGS on *A comparison of Katmai with the craters described by Mr. Sargent;* and E. C. CRITTENDEN on *The excessive sensitivity to red light of red-color-blind persons.*

Mr. K. Y. TSUKUDA in charge of the Magnetic Chart and Marine Metrological Division of the Imperial Marine Observatory, Kobe, Japan, called at the various Scientific Bureaus while on a visit in Washington.

Mr. O. W. TORRESON of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington will leave the Magnetic Observatory at Watheroo, Australia, early in June to return to Washington.